Percentage Composition/ Empirical and Molecular Formula Worksheet

Give the % composition of all elements in these compounds. ***Show all work!***

1) ammonium sulfite

2) aluminum acetate

3) calcium oxalate

4) aluminum bromate

5) sodium hypoiodite

1. $(NH_4)_2SO_3$ = 152.2 g/mol

%N = $\frac{28.02\,g}{152.2\,g} \times 100$ = 18.40%

% H = $\frac{4.032\,g}{152.2\,g} \times 100$ = 2.64%

%S = $\frac{32.07\,g}{152.2\,g} \times 100$ = 21.07%

%O = $\frac{48.0\,g}{152.2\,g} \times 100$ = 31.53%

$Al(C_2H_3O_2)_3$ = 204.1 g/mol

Al $\frac{26.98\,g}{204.1\,g}$ = 13.22%

%H = $\frac{9.07\,g}{204.1\,g} \times$ = 4.44%

%C $\frac{72.06\,g}{204.1\,g}$ = 35.30%

%O $\frac{96\,g}{204.1\,g}$ = 47.03%

CaC_2O_4 = 128.1 g

%Ca = $\frac{40.08\,g}{128.1\,g}$ = 31.29%

%C = $\frac{24\,g}{128.1\,g}$ = 18.73%

%O $\frac{64\,g}{128.1\,g} \times 100$ = 49.97%

$Al(BrO_3)_3$ = 410.7 g/mol

%Al = $\frac{26.98\,g}{410.7\,g}$ = 6.57%

Br = $\frac{239.7\,g}{410.7\,g}$ = 58.37%

O = $\frac{144\,g}{410.7\,g}$ = 35.06%

NaIO = 165.9 g/mol

%Na = $\frac{22.99\,g}{165.9\,g}$ = 13.85%

%I $\frac{126.9\,g}{165.9\,g}$ = 76.50%

%O = $\frac{16.00\,g}{165.9\,g}$ = 9.64%

Solve the following problems on empirical and molecular formulas.

1) What's the empirical formula of a molecule containing 65.5% carbon, 5.5% hydrogen, and 29.0% oxygen?

$65.5\,g\,C \times \frac{1\,mol}{12\,g} = 5.46\,mol\,C$ / 3.01 mol C

$5.5\,g\,H \times \frac{1\,mol}{1\,g} = 5.5\,mol\,H$ / 1.81 = 3.03 mol H

$29.0\,g\,O \times \frac{1\,mol}{16\,g} = 1.81\,g\,O$ / 1 mol O

$= C_3H_3O$ = 55

×2

2) If the molar mass of the compound in problem 1 is 110 grams/mole, what's the molecular formula?

$C_6H_6O_2$ #6

3) What's the name of a the compound containing 18.7% lithium, 16.3% carbon, and 65.0% oxygen?

$18.7\,g\,Li \times \frac{1\,mol}{6.94} = 2.69\,mol\,Li$ / 2 mol Li — Li_2CO_3

$16.3\,g\,C \times \frac{1\,mol}{12.0\,g} = 1.36\,mol\,C$ / 1.36 — 1 mol C — Lithium Carbonate

$65.0\,g\,O \times \frac{1\,mol}{16.0\,g} = 4.06\,mol\,O$ — 3 mol O

4) Menthol, the substance we can smell in mentholated cough drops, is composed of C, H, and O. A 0.1005 g sample is combusted, producing a 0.2829 g of carbon dioxide and 0.1159 g of water. What is the empirical formula for menthol? What is the molecular formula if its molar mass is 156 g/mol?

$0.1005\,g - 0.07727\,g - 0.0128\,g = 0.01040\,g\,O \times \frac{1\,mol}{16.01\,g} = 0.000649\,mol\,O$

65

1 mol / 10

$0.2829\,g\,CO_2 \times \frac{1\,mol\,CO_2}{44.0\,g\,CO_2} \times \frac{1\,mol\,C}{1\,mol\,CO_2} \times \frac{12.01\,g\,C}{1\,mol\,C} \frac{0.07727\,g\,C}{12.0\,g} = 0.006414\,mol\,C$

8.66 mol C

×2

$0.1159\,g\,H_2O \times \frac{1\,mol\,H_2O}{18.0\,g\,H_2O} \times \frac{2\,mol\,H}{1\,mol\,H_2O} \times \frac{1\,g\,H}{1\,mol\,H} = 0.01287\,g\,H$ / 1.0 g

$= 0.01287\,mol\,H$

16.42 mol H

19.8 → 20

$C_{10}H_{20}O$

Balancing Equations and Stoichiometry

Balance the following equations

1) 2 C_6H_6 + 15 O_2 → 6 H_2O + 12 CO_2

2) 4 NaI + __ $Pb(SO_4)_2$ → __ PbI_4 + 2 Na_2SO_4

3) 4 NH_3 + 5 O_2 → 4 NO + 6 H_2O

4) 2 $Fe(OH)_3$ → __ Fe_2O_3 + 3 H_2O

5) 2 HNO_3 + __ $Mg(OH)_2$ → 2 H_2O + __ $Mg(NO_3)_2$

6) __ H_3PO_4 + 3 NaBr → 3 HBr + __ Na_3PO_4

7) 3 C + 4 H_2 → __ C_3H_8

8) 2 CaO + __ MnI_4 → __ MnO_2 + 2 CaI_2

9) __ Fe_2O_3 + 3 H_2O → 2 $Fe(OH)_3$

10) __ C_2H_2 + 2 H_2 → __ C_2H_6

11) 2 VF_5 + 10 HI → __ V_2I_{10} + 10 HF

12) __ OsO_4 + 2 $PtCl_4$ → 2 PtO_2 + __ $OsCl_8$

13) __ CF_4 + 2 Br_2 → __ CBr_4 + 2 F_2

14) 2 Hg_2I_2 + __ O_2 → 2 Hg_2O + 2 I_2

15) __ $Y(NO_3)_2$ + __ $GaPO_4$ → __ YPO_4 + __ $Ga(NO_3)_2$

Stoichiometry

1) When sodium hydroxide reacts with carbon dioxide it produces sodium carbonate and water. When 10.23 g of sodium hydroxide is used with an excess of carbon dioxide, what mass and volume of water is produced? $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

$$10.23\,g\,NaOH \times \frac{1\,mol\,NaOH}{40.0\,g\,NaOH} \times \frac{1\,mol\,H_2O}{2\,mol\,NaOH} \times \frac{18.0\,g\,H_2O}{1\,mol\,H_2O} = 2.302\,g\,H_2O \times \frac{1\,g\,H_2O}{1\,mL} = 2.302\,mL\,H_2O$$

ammonia

2) If 24.3 g of aluminum nitride react with 10.3 g of water to produce aluminum hydroxide and ~~hydronitric~~ acid, what is the percent yield if only 2.015 g of aluminum hydroxide is recovered?

$$AlN + 3H_2O \longrightarrow NH_3 + Al(OH)_3$$

$$24.3\,g\,AlN \times \frac{1\,mol\,AlN}{41\,g\,AlN} = 0.593\,mol\,AlN \text{ (Have)} \times \frac{3\,mol\,H_2O}{1\,mol\,AlN} = 1.77\,mol\,H_2O$$

$$10.3\,g\,H_2O \times \frac{1\,mol\,H_2O}{18\,g\,H_2O} = 0.572\,mol\,H_2O \times \frac{1\,mol\,Al(OH)_3}{3\,mol\,H_2O} \times \frac{78\,g\,Al(OH)_3}{1\,mol\,Al(OH)_3} = 14.88\,g\,Al(OH)_3$$

$$\frac{2.015\,g}{14.88\,g\,Al(OH)_3} \times 100\% = 13.54\%$$

3) Solutions of sulfurfic acid and lead (II) acetate react to from solid lead (II) sulfate and acetic acid. If 7.50 g of sulfuric acid and and 7.50 g of lead (II) acetate are mixed, calculate the number of grams of each reactant and product present after the reaction is completed.

$$H_2SO_4 + Pb(C_2H_3O_2)_2 \longrightarrow PbSO_4\downarrow + 2HC_2H_3O_2$$

(0 g left)

$$7.50\,g\,H_2SO_4 \times \frac{1\,mol\,H_2SO_4}{98\,g\,H_2SO_4} = 0.0765\,mol\,H_2SO_4 - 0.0231\,mol\,H_2SO_4 = 0.0534\,mol\,H_2SO_4 \times \frac{98\,g\,H_2SO_4}{1\,mol\,H_2SO_4} = 5.23\,g\,H_2SO_4$$

$$7.50\,g\,PbSO_4 \times \frac{1\,mol\,Pb(OAc)_2}{325\,g\,Pb(OAc)_2} = 0.0231\,mol\,PbSO_4 \text{ (Have)} \times \frac{1\,mol\,H_2SO_4}{1\,mol\,PbSO_4} = 0.0231\,mol\,H_2SO_4 \text{ need}$$

LR

$$0.0231\,mol\,Pb(OAc)_2 \times \frac{1\,mol\,PbSO_4}{1\,mol\,Pb(OAc)_2} \times \frac{303\,g\,PbSO_4}{1\,mol\,PbSO_4} = 7.14\,g\,PbSO_4$$

$$0.0231\,mol\,Pb(OAc)_2 \times \frac{2\,mol\,HOAc}{1\,mol\,Pb(OAc)_2} \times \frac{60\,HOAc}{1\,mol\,HOAc} = 2.77\,g\,HOAc$$

4) When hydrogen sulfide gas is bubbled into a solution of sodium hydroxide, the reaction forms sodium sulfide and water. How many grams of sodium sulfide are formed if the solution used contains 2.00 grams of sodium hydroxide and the reaction has a 92.0% yield? How many molecules of hydrogen sulfide reacted? $H_2S + 2NaOH \longrightarrow Na_2S + H_2O$

$$2.00\,g\,NaOH \times \frac{1\,mol\,NaOH}{40\,g\,NaOH} \times \frac{1\,mol\,Na_2S}{2\,mol\,NaOH} \times \frac{78\,g\,Na_2S}{1\,mol\,Na_2S} \times 0.920 = 1.79\,g\,Na_2S$$

$$\frac{1\,mol\,H_2S}{2\,mol\,NaOH} \times \frac{6.022\times10^{23}\,molec\,H_2S}{1\,mol\,H_2S} = 1.51\times10^{22}\,molec\,H_2S$$

Harder Practice Problems for Chapter 3

Multiple Choice- YOU CANNOT USE A CALCULATOR FOR THESE

1. How many moles of hydrogen sulfide are contained in a 66.0-g sample of this gas?

A) 0.52 mol
B) 1.94 mol
C) 100.1 mol
D) 32.7 mol
E) 3.87 mol

2) When the following equation is balanced, the coefficients are _____.

$$Al(NO_3)_3 + Na_2S \rightarrow Al_2S_3 + NaNO_3$$

A) 2, 3, 1, 6
B) 2, 1, 3, 2
C) 1, 1, 1, 1
D) 4, 6, 3, 2
E) 2, 3, 2, 3

3) Magnesium and nitrogen react in a combination reaction to produce magnesium nitride:

$$3\,Mg + N_2 \rightarrow Mg_3N_2$$

In a particular experiment, a 9.27-g sample of N_2 reacts completely. The mass of Mg consumed is _____ g.

A) 8.04
B) 24.1
C) 16.1
D) 0.92
E) 13.9

4) The combustion of propane (C_3H_8) produces CO_2 and H_2O:

$$C_3H_8\,(g) + 5O_2\,(g) \rightarrow 3CO_2\,(g) + 4H_2O\,(g)$$

The reaction of 2.5 mol of O_2 will produce _____ mol of H_2O.

A) 4.0
B) 3.0
C) 2.5
D) 2.0
E) 1.0

5) Calcium carbide (CaC_2) reacts with water to produce acetylene (C_2H_2):

$$CaC_2\,(s) + 2H_2O\,(g) \rightarrow Ca(OH)_2\,(s) + C_2H_2\,(g)$$

Production of 13g of C_2H_2 requires consumption of _____ g of H_2O.

A) 4.5
B) 9.0
C) 18
D) 4.8×10^2
E) 4.8×10^{-2}

6) The formula of nitrobenzene is $C_6H_5NO_2$. The molecular weight of this compound is _____ amu.

A) 107.11
B) 43.03
C) 109.10
D) 123.11
E) 3.06

7) The mass % of H in methane (CH_4) is _____.

A) 25.13
B) 4.032
C) 74.87
D) 92.26
E) 7.743

8) One mole of _____ contains the largest number of atoms.

A) S_8
B) $C_{10}H_8$
C) $Al_2(SO_4)_3$
D) Na_3PO_4
E) Cl_2

9) How many molecules of CH_4 are in 48.2 g of this compound?

A) 5.00×10^{24}
B) 3.00
C) 2.90×10^{25}
D) 1.81×10^{24}
E) 4.00

10) A compound has 1.10 mol of K, 0.55 mol of Te, and 1.65 mol of O. What is the simplest formula for this compound?

A) KTeO
B) KTe_2O
C) K_2TeO_3
D) K_2TeO_6
E) K_4TeO_6

Problems-Answer these on a separate sheet of paper.

1. Consider a sample of calcium carbonate in the form of a cube measuring 2.005 in. on each edge. If the sample has a density of 2.71 g/cm^3, how many oxygen atoms does it contain?

2. If an automobile travels 225 mi with a gas mileage of 20.5 mi/gal, how many kilograms of CO_2 were produced? Assume gasoline is composed only of octane (C_8H_{18}), which has density of 0.69 g/mL.

3. When hydrocarbons are burned in a limited amount of air, both CO and CO2 from. When 0.450 g of a particular hydrocarbon was burned in air, 0.467 g of CO, 0.733 g of CO2, and 0.450 g of H2O were formed.

a. What is the empirical formula of the compound?
b. How many grams of oxygen were used in the reaction?
c. How many grams of oxygen would have been required for complete combustion?

Harder Problems Ch 3

① $2.00\,\text{in} \times \frac{2.54\,\text{cm}}{1\,\text{in}} = (5.093\,\text{cm})^3 = 132.1\,\text{cm}^3 \times \frac{2.71\,\text{g}}{\text{cm}^3} \times \frac{1\,\text{mol}\,CaCO_3}{100\,\text{g}\,CaCO_3} \times \frac{6\times10^{23}\,\text{f.u.}\,CaCO_3}{1\,\text{mol}\,CaCO_3} =$

$= 2.16\times10^{24}\,\text{f.u.}\,CaCO_3 \times \frac{3\,\text{atoms O}}{1\,\text{f.u.}\,CaCO_3} = 6.47\times10^{24}\,\text{atoms O}$

② $225\,\text{mi} \times \frac{1\,\text{gal}}{20.5\,\text{mi}} \times \frac{3.78\,\text{L oct}}{1\,\text{gal each}} \times \frac{1000\,\text{mL}}{1\,\text{L}} \times \frac{0.69\,\text{g}}{1\,\text{mL}} = 2.86\times10^{4}\,\text{g Oct}$

$2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$

$2.86\times10^{4}\,\text{g oct} \times \frac{1\,\text{mol Oct}}{114\,\text{g Oct}} \times \frac{16\,CO_2}{2\,\text{mol Oct}} \times \frac{44.0\,\text{g}\,CO_2}{1\,\text{mol}\,CO_2} \times \frac{1\,\text{kg}}{1000\,\text{g}} = 88.4\,\text{kg}\,CO_2$

③ 0.450 g of H Carbon

$C_xH_x + O_2 \longrightarrow CO_2 + CO + H_2O$

$0.733\,\text{g} \quad 0.467\,\text{g} \quad 0.450\,\text{g}$

a $0.733\,\text{g}\,CO_2 \times \frac{1\,\text{mol}\,CO_2}{44.0\,\text{g}\,CO_2} \times \frac{1\,\text{mol C}}{1\,\text{mol}\,CO_2} = 0.0167\,\text{mol C}$

$0.467\,\text{g CO} \times \frac{1\,\text{mol CO}}{28\,\text{g CO}} \times \frac{1\,\text{mol C}}{1\,\text{mol CO}} = 0.0167\,\text{mol C}$

$0.0333\,\text{mol C} : 0.0500\,\text{mol H}$

$1\,\text{mol C} : 1.5\,\text{mol H}$

C_2H_3

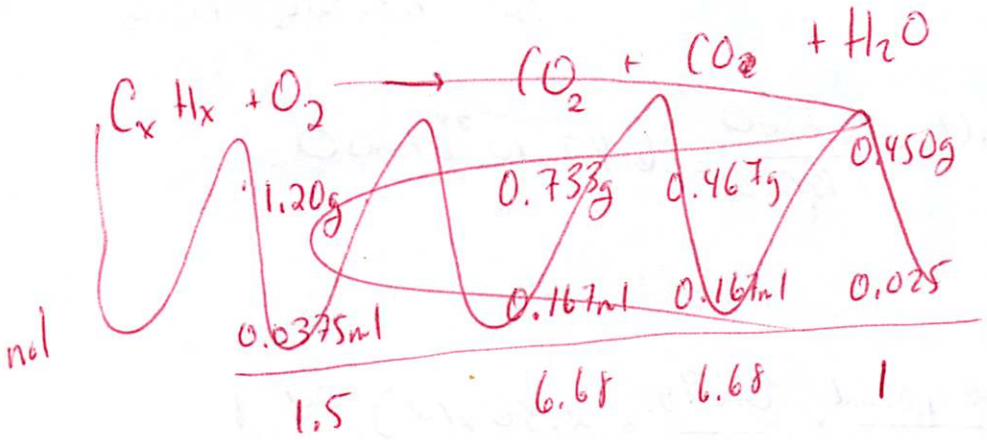
$0.450\,\text{g} \times \frac{1\,\text{mol}\,H_2O}{18.0\,\text{g}\,H_2O} \times \frac{2\,\text{mol H}}{1\,\text{mol}\,H_2O} = 0.0500\,\text{mol H}$

b $0.733\,\text{g}\,CO_2 \times \frac{1\,\text{mol}\,CO_2}{44\,\text{g}\,CO_2} \times \frac{2\,\text{mol O}}{1\,\text{mol}\,CO_2} \times \frac{1\,\text{mol}\,O_2}{2\,\text{mol O}} \times \frac{32\,\text{g}\,O_2}{1\,\text{mol}\,O_2} = 0.533\,\text{g}\,O_2$

$0.467\,\text{g CO} \times \frac{1\,\text{mol CO}}{28\,\text{g CO}} \times \frac{1\,\text{mol O}}{1\,\text{mol CO}} \times \frac{1\,\text{mol}\,O_2}{2\,\text{mol O}} \times \frac{32\,\text{g}\,O_2}{1\,\text{mol}\,O_2} = 0.267\,\text{g}\,O_2$

$1.20\,\text{g}\,O_2$

$0.450\,\text{g}\,H_2O \times \frac{1\,\text{mol}\,H_2O}{18.0\,\text{g}\,H_2O} \times \frac{1\,\text{mol O}}{1\,\text{mol}\,H_2O} \times \frac{1\,\text{mol}\,O_2}{2\,\text{mol O}} \times \frac{32\,\text{g}\,O_2}{1\,\text{mol}\,O_2} = 0.400\,\text{g}\,O_2$



$2CO + O_2 \rightarrow 2CO_2$

C $0.467\,g\,CO \times \frac{1\,mol\,CO}{28.0\,g\,CO} = 0.01668\,mol\,CO \times \frac{1\,mol\,O_2}{2\,mol\,CO} \times \frac{32\,g\,O_2}{1\,mol\,O_2} = 0.267\,mg\,O_2$

$0.267\,g\,O_2 + 1.20\,g\,O_2 = \boxed{1.47\,g\,O_2}$